Use of two Bt formulations for

Department of
Agriculture

Forest
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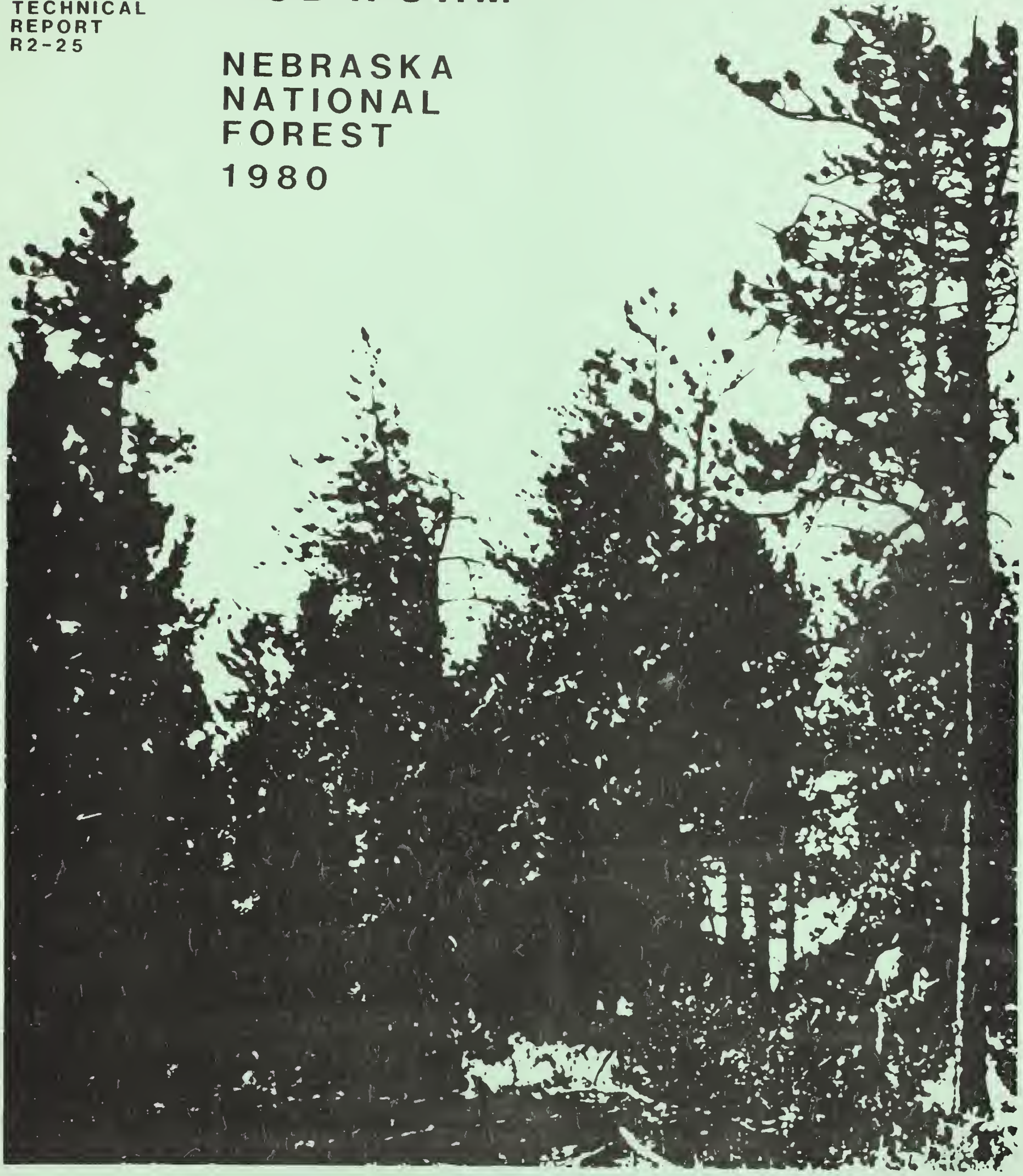
Management

TECHNICAL
REPORT
R2-25

SUPPRESSION OF JACK PINE BUDWORM

NEBRASKA NATIONAL FOREST 1980



Use of Two *Bt* Formulations For Suppression Of Jack Pine Budworm

Nebraska National Forest

1980

by

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Technical Report R2-25

June 1981

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ACKNOWLEDGEMENTS

The author acknowledges assistance of the following members of the Region 2 Forest Pest Management Staff during various phases of this project: J. Allen, L. Disbrow, M. Eilers, M. Hansen, L. Fuller, K. Lister, M. McWilliams, S. Nay, C. O'Neil, B. Raimo, and W. White. The assistance of Nebraska National Forest personnel, especially W. Dubois, S. Marquardt, D. Roseberry, and G. Teahon, is appreciated.

INTRODUCTION

The jack pine budworm, *Choristoneura pinus* Freeman, has been recognized as the principal defoliator of jack pine, *Pinus banksiana* Lambert, in the Lake States region for about 60 years (Foltz et al. 1972). Reported tree losses have been quite variable, the majority being in the suppressed and intermediate size classes (Allen et al. 1968). However, severe infestations may substantially reduce tree growth under all stand conditions (Benjamin et al. 1961).

C. pinus [1/] was first detected in the non-native jack pines of the Nebraska National Forest in 1978 (James 1979). These stands were planted between 1903 and 1941 in the sandhills of north-central Nebraska approximately 400 miles (644 km) southwest of the closest extremity of the natural range of jack pine (Rudolf and Schoenike 1963). Although not reported, apparently there were pockets of heavy jack pine budworm defoliation in 1978. In July 1979, personnel from the Nebraska National Forest noticed areas of jack pine with heavy defoliation and requested help from entomologists in evaluating the severity of the defoliation and identifying the insect species responsible.

After sampling egg masses during August 1979, it was suggested that the Nebraska National Forest consider a suppression project in 1980. This project would reduce the budworm population to help maintain current levels of tree vigor until the Forest decided what management strategies would be employed in these stands of jack pine.

This report details the methods used in and the results of a suppression project using *Bacillus thuringiensis* against *C. pinus* Freeman.

[1/] The specific determination was made by Dr. P. T. Dang, Biosystematics Research Institute, Ottawa, Ontario, Canada.

PROJECT AREA

The project was conducted near Halsey, Nebraska, on the Bessey Ranger District of the Nebraska National Forest (Fig. 1). This planted forest is located in the sandhills of north-central Nebraska. The jack pine was planted in blocks of 1-300 acres (0.4 - 121.4 hectares) intermixed with blocks of ponderosa pine, *P. ponderosa* Laws., and eastern redcedar, *Juniperus virginiana* L. Most of the planting blocks containing jack pine are pure jack pine stands; however, some of the blocks contain mixed stands of jack pine along with ponderosa pine and/or eastern redcedar.

INSECTICIDES

Description

Thuricide-16B and Dipel 4L were applied during this project.

Thuricide-16B is a microbial insecticide whose active ingredient is based on a bacterium, *Bacillus thuringiensis* Berliner, variety *kurstaki* (serotype IIIa, IIIb). This is commonly called the HD-1 strain. It is a free flowing liquid with a viable spore count of at least 5×10^9/mg and an insecticidal activity of four billion International Units (BIU)/qt (3.8 BIU/ℓ) or 3300 International Units (IU)/mg. Density is 1.17 - 1.22 and the pH of a 2% solution in distilled water is 6.0 - 7.0. Insecticidal activity is stable for four years at 50°F (10°C) and for two years at 70-77°F (21-25°C).

Dipel 4L is also a microbial insecticide whose active ingredient is based on the HD-1 strain of *B. thuringiensis*. It is a free flowing emulsifiable suspension with an insecticidal activity of 8 BIU/qt (7.6 BIU/ℓ) or 8800 IU/mg. Density is 1.0 and insecticidal activity is stable for two years at 98°F (37°C).

Both of the above *Bt* formulations are highly selective insecticides for use against certain lepidopterous larvae. Both are registered with the Environmental Protection Agency for use against *C. pinus*.

Handling and Mixing

Both Thuricide-16B and Dipel 4L were shipped in 55 gal (208.2 ℓ) drums with each Thuricide-16B drum containing 53 gal (200.7 ℓ) of product and each Dipel 4L drum containing 54 gal (204.4 ℓ) of product.

All material was mixed the same day that it was applied. Insecticides were mixed in 200-gal (757.1 ℓ) fiberglass mixing tanks; a different tank for each insecticide.

The mixing of the insecticides consisted of adding 100 gal (378.5 ℓ) of Thuricide-16B to 100 gal (378.5 ℓ) of tap water, or 50 gal (189.3 ℓ) of Dipel 4L to 150 gal (567.8 ℓ) of water. Each mixture yielded an insecticidal activity of 8 BIU/gal (2.1 BIU/ℓ). Empty barrels were rinsed and buried in a designated insecticide disposal area.

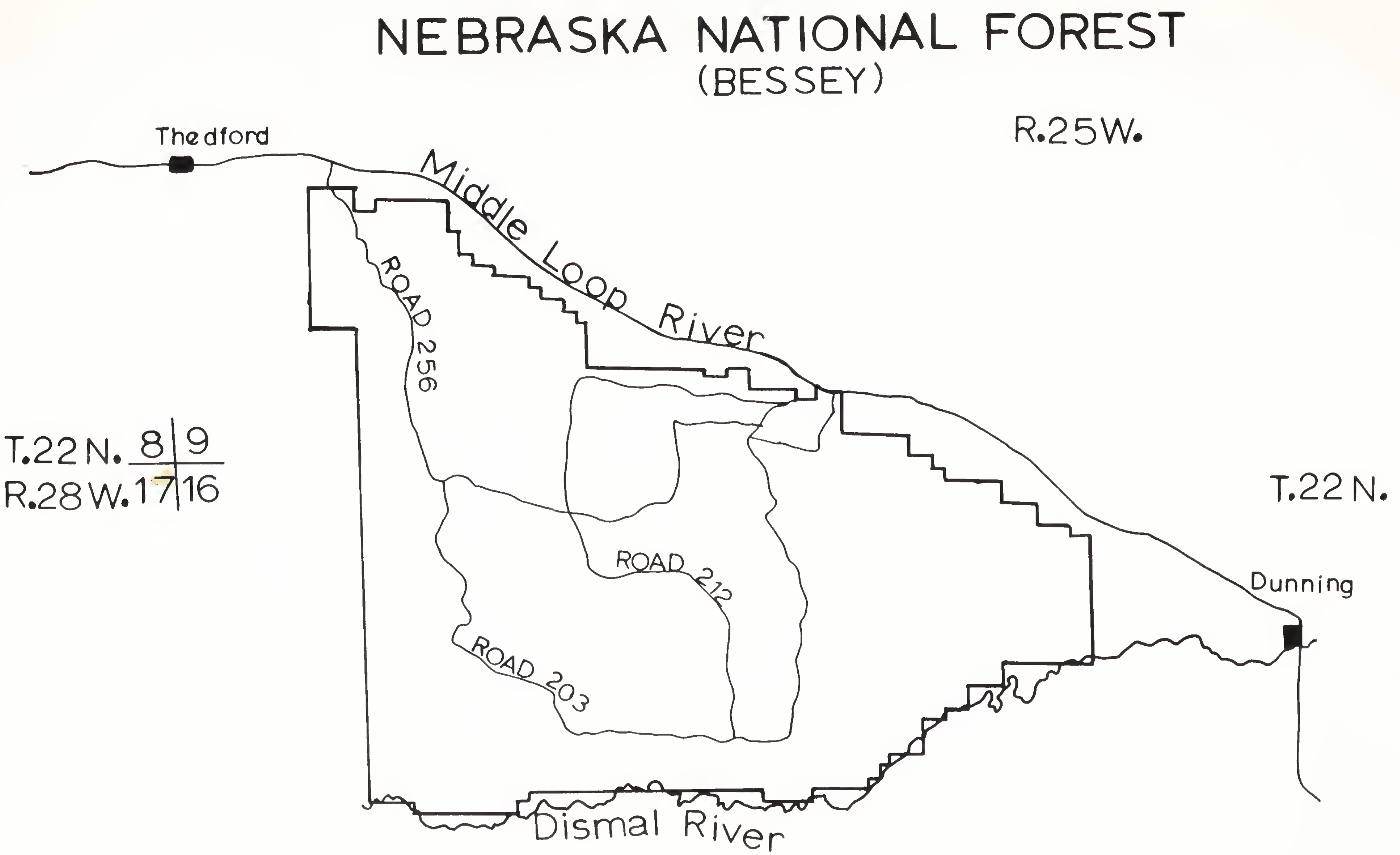


Figure 1. Map showing boundaries of the Bessey Ranger District of the Nebraska National Forest.

PROJECT DESIGN

Block and Treatment Selection

Resource managers indicated an urgent need for suppression of the jack pine budworm in 1980. Originally, this project was conceived as being an operational project since both Thuricide-16B and Dipel 4L were registered with the Environmental Protection Agency. However, because of the scarcity of data dealing with aerial application of *Bt* against jack pine budworm (i.e., only two tests could be documented[2,3] and neither used Dipel 4L) it was decided that the project should be designed similar to a pilot project. *Bt* would be applied to most all of the jack pine stands except for the two areas left as check blocks.

Because of the extremely scattered nature of the jack pine stands, the spray blocks varied considerably in size and shape (Fig. 2). Also, it was not economically feasible to delineate and spray each jack pine stand separately. Spray blocks contained various mixtures of jack pine, ponderosa pine, eastern redcedar and open grassland. Rather than selecting an equal number of blocks for each insecticide, blocks were selected such that the total area sprayed by each insecticide was approximately the same. The treatment designated for and size of each block was as follows:

Block No.	Treatment	Acres (Hectares)
1	Thuricide-16B	1000 (405)
5	Dipel 4L	1800 (728)
8	Thuricide-16B	420 (170)
10	Thuricide-16B	240 (97)
12	Thuricide-16B	200 (81)
13	Untreated	240 (97)
14	Untreated	470 (190)

Sampling Design

The insect sampling design was drastically altered from that required for reliable statistical comparisons because of severe restrictions placed upon the project concerning mileage traveled and number of personnel that could be hired. Foltz et al. (1968) recommended a 10-tree sampling cluster for each ten acres

[2]Knowles, K. 1980. Experimental Aerial Application of Novabac-3 for control of jack pine budworm. Manitoba Dept. of Nat. Res., Parks Division, Winnipeg, Manitoba. Unpubl. Rep.

[3]Miller, S. 1975. Project No. US FEP 501/75, Report No. SM 75015, Trial No. I3049-12. Sandoz, Inc. Unpubl. Rep.

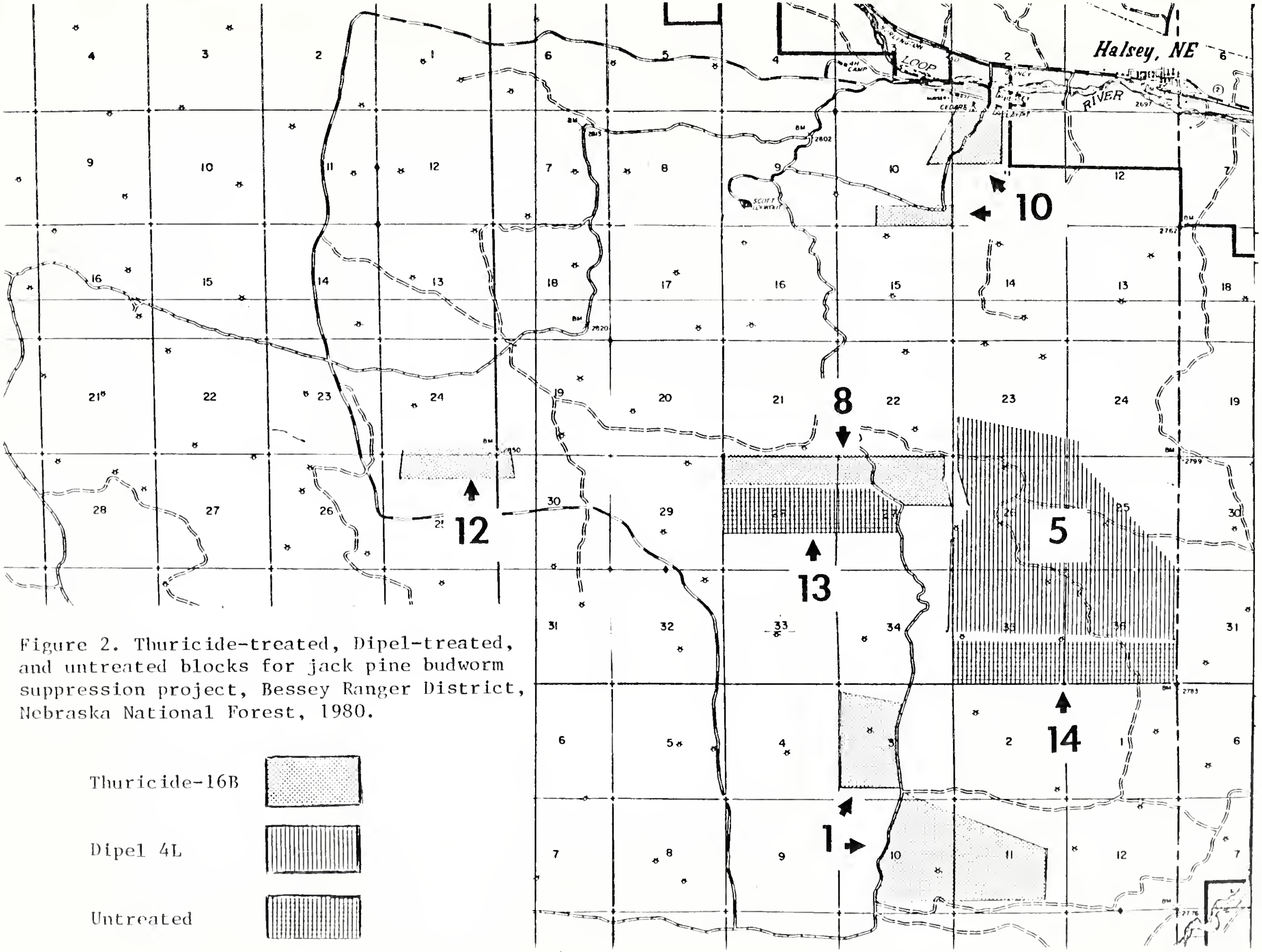


Figure 2. Thuricide-treated, Dipel-treated, and untreated blocks for jack pine budworm suppression project, Bessey Ranger District, Nebraska National Forest, 1980.

(4.0 ha) of jack pine, but this would have been impractical even before our additional restrictions. For this project, it was planned to select one sampling cluster of ten trees (Foltz et al. 1968) for ca. each 40 acres (16.2 ha) of jack pine within spray blocks. This design would have required approximately 60 sampling clusters or 600 trees and 120 person-days for each sampling period. Instead, because of restrictions, the number of trees per cluster and the number of clusters were lowered.

Clusters of five trees each were distributed throughout the jack pine stands with totals of 30 and 10 clusters in the treated and untreated blocks, respectively. Cluster locations were marked on 7.5 minute USGS photomosaic maps and on the ground by plastic flagging. Sample trees were each marked with a numbered metal tag and plastic flagging.

DATA COLLECTION

Larval Development Sampling

The first larval development samples were collected on May 22, 1980. Since most all larvae were still feeding within the staminate cone clusters, the next samples were not collected until May 28. Daily larval development samples were collected until it was determined that most of the larvae were in the fourth or fifth instar and were feeding on the current year's foliage. At this time, prespray larval sampling began.

Jack pine budworm larvae collected during developmental sampling were transported daily to the makeshift laboratory in the Bessey District Headquarters building. Larval instar was determined by head capsule measurement using a binocular dissecting microscope equipped with a micrometer. Measurements were recorded daily.

Prespray and Postspray Sampling

Four branches, each approximately 24 in (6.1 cm) long, were taken from each tree in each cluster at a height of 25-35 ft (7.6-10.7 m) using a telescoping pole pruner with attached catch basket. For each sampled branch, the number of larvae and the number of tips[4/] were counted and recorded in the field. Up to 50 larvae collected from each cluster were preserved and the head capsules measured. Data for the two postspray sampling periods were collected in the same manner as that of the prespray sampling period.

[4/] The definition used for tip is the same as that used by Foltz et al. (1972); i.e., any shoot bearing or having borne needle growth of the current year.

Spray Deposit Assessment

Spray deposit assessment was attempted by placing four Kromekote® cards, one in each cardinal direction, along the drip line of one sample tree in each cluster and four cards in the opening nearest each cluster. Cards were placed in plastic holders which had been stapled to 14-in (35.6 cm) wooden stakes to keep the cards above ground vegetation.

Spray deposit cards were retrieved as soon as was feasible after application of insecticide to each spray block. Cards from each block were placed into separate envelopes. Later the cards were examined for presence or absence of spray droplets to determine if the insecticide had or had not been applied to that specific site.

Defoliation Assessment

Defoliation estimates were not made on individual branch samples. Defoliation is highly variable between branches within the same tree and there is no accurate documented method of estimating defoliation caused by *C. pinus*. Thus, it was decided that crude ocular defoliation estimates (light, medium or heavy) of whole trees or groups of trees within spray blocks would suffice for this project.

Egg Mass Sampling

Egg mass sampling, accomplished during the period of July 29 to September 14, 1981, was minimal due to previously mentioned restrictions. Four approximately 24-in (6.1 cm) branches were collected at heights of 25-35 ft (7.6 10.7 m) from trees near the tagged cluster-trees. Tagged trees were not sampled since they had been considerably altered during larval sampling (i.e., 12 branches had been removed from each tree). Only one tree was sampled near each of the 18 clusters in blocks 5 and 14 (Fig. 2) due to low insect populations and very little 1980 defoliation. Five trees were sampled near each of the 22 clusters in the remaining blocks. The first 100 branches collected were examined in the field for presence of egg masses. The remainder were placed into paper bags, labeled, and transported to Lakewood, Colorado, for examination in the laboratory.

SPRAY OPERATIONS

The aircraft contracted for the insecticide application consisted of two Grumman AgCats each equipped with standard spray booms. Each spray boom was equipped with 18 TeeJet® spray nozzles with disc-core type (D6-46) cone spray tips[5/]. Nozzles were directed straight back. Both airplanes were equipped with Kam-Lok quick disconnect fittings and non-leaking valves on the filler ports.

5/Manufactured by Spraying Systems Corporation, North Avenue at Schmale Road, Wheaton, Illinois 60187.

Characterization of the spray mixture was done in the field using procedures similar to those described by Maksymiuk (1978). Thuricide-16B was applied with a system pressure of 40 psi at a height of 25 ft (7.6 m) and an airspeed of 100 mph (44.7 m/sec). This resulted in a VMD[6/] of 293 μm, a swath width of ca. 100 ft (30.5 m), and an application rate of ca. 1 gal/acre (9.4 ℓ/ha). Due to an error, characterization of Dipel 4L was not done until after the project was completed. It was erroneously believed that the VMD of Dipel 4L would be similar to that of Thuricide-16B. Characterization of Dipel 4L, using the same application criteria showed an average VMD of 170 μm.

Meteorological conditions were monitored at the airport and recorded prior to the departure of each insecticide load. Data obtained were: dry bulb temperature, wet bulb temperature, wind speed and direction, wind stability, and time.

COMMUNICATIONS

Communications equipment was borrowed from the Boise Interagency Fire Center, Boise, Idaho. A battery operated repeater was placed near the Scott Lookout Tower which is at one of the highest points (2940 ft [896 m]) within the Forest. A three-channel base transceiver was located at the airport (i.e., operations base), each field crew was equipped with a three-channel, hand-held portable transceiver, and a similar transceiver was placed in the District Headquarters. Thus, communication between the field crews, base operations personnel, and District Headquarters was possible at all times during sampling and spray operations.

Each spray aircraft and the chase plane were equipped with a three-channel pack radio with boom microphone and headphone-equipped crash helmet. This allowed spray pilots and chase plane observer to communicate with each other as well as with ground crews and with base operations personnel.

BUDGET SUMMARY

Table 1 shows the actual project costs. Cost of egg mass sampling was not included since this would have been done in the absence of a suppression project.

[6/] Volume median diameter is the diameter estimated from a group of droplets such that half of the liquid volume is in the form of droplets with diameters larger than the VMD and half smaller.

TABLE 1. Cost of 1980 Jack Pine Budworm Suppression Project on the Nebraska National Forest.

ITEM	COST
Aircraft	
Two Fixed-Wing Spray Planes	$ 8,237.00
Chase Plane	2,500.00
Pesticide	
Thuricide-16B	12,084.00
Dipel 4L	12,600.00
Pesticide Mixing & Handling Equipment	2,128.00
Field and Laboratory Equipment	3,499.00
Project Salaries	31,064.00
Travel and Per Diem	9,234.00
TOTAL	$81,346.00

RESULTS AND DISCUSSION

The spraying operation commenced when approximately 50% of the larvae collected during development sampling were in the fifth instar. All blocks were released for spraying on the same date since larval development appeared to be progressing at a similar rate on all jack pine stands sampled.

Spraying began on the evening of June 6, 1980. One aircraft was loaded with Thuricide-16B and the other with Dipel 4L. Two loads (400 gal [1514 ℓ]) were applied by each aircraft before operations were shut down due to an approaching thunderstorm. It began raining approximately four hours after the last load had been applied and rained 0.06 inches (0.15 cm) at the northern end of the Forest where the Bessey District weather station is located. Several problems were encountered on these initial spray runs. First, the helium-filled weather balloons at the corners of the blocks were not readily visible to the spray pilots. Secondly, the chase plane observer was experiencing difficulty in monitoring two spray aircraft spraying in different blocks.

No insecticides were applied on June 7, but on June 8 weather conditions were ideal. The operational problems encountered initially were resolved by having one person with a helium balloon attached to fishing line stationed at each end of the block being sprayed. As each pass was completed the person would advance to the position of the next swath until the block was completely covered.

The two aircraft were both loaded with the same type of insecticide and flew in tandem on this day, allowing the chase plane observer to better monitor the spraying operations. Several extra passes were made over areas in Blocks 8 and 5 where the lack of insecticide on spray deposit cards indicated that they were skipped during the June 6 operations.

The overall unadjusted population reduction in the Thuricide-treated blocks and the Dipel-treated blocks was 89.6% and 86.0% respectively (Table 2). Due to inadequate numbers of sampling clusters, it is not statistically possible to determine differences in population levels between blocks. However, there did appear to be general differences between population levels in different blocks. Blocks 1, 8, 10, and 13 seemed to have higher levels than Blocks 5, 12, and 14 (Table 3). When estimating the adjusted mortality (Table 2) the Thuricide-treated blocks and the Dipel-treated block were compared to untreated Blocks 13 and 14 respectively (Fig. 3). One cannot compare the efficacies of the two *Bt* formulations used because of apparent differences in population levels and inadequate sampling size.

Crude visual estimates of trees and groups of trees within and/or near sampling clusters indicated there was no apparent foliage protection in treated areas. This was expected since many fourth and some third instar larvae begin to clip off and feed on current year's needles when needles start to expand. During this time larvae do not actively wander around the foliage, but spend most of the time within silken tunnels. By the time half the larvae are in the fifth instar most of the defoliation has occurred.

TABLE 2. Unadjusted and Adjusted Jack Pine Budworm Mortalities for Thuricide-treated and Dipel-treated Areas, Jack Pine Budworm Suppression Project, Nebraska National Forest, 1980

	11-Day Postspray Mortality (percent)		18-Day Postspray Mortality (percent)	
	Thuricide	Dipel	Thuricide	Dipel
Unadjusted[1/]	85.1	77.6	89.6	86.0
Adjusted by Abbott's formula[2/]	87.4	70.7	88.5	76.3

1/ Unadjusted mortality = $1 - \frac{\text{postspray}}{\text{prespray}} \quad 100$

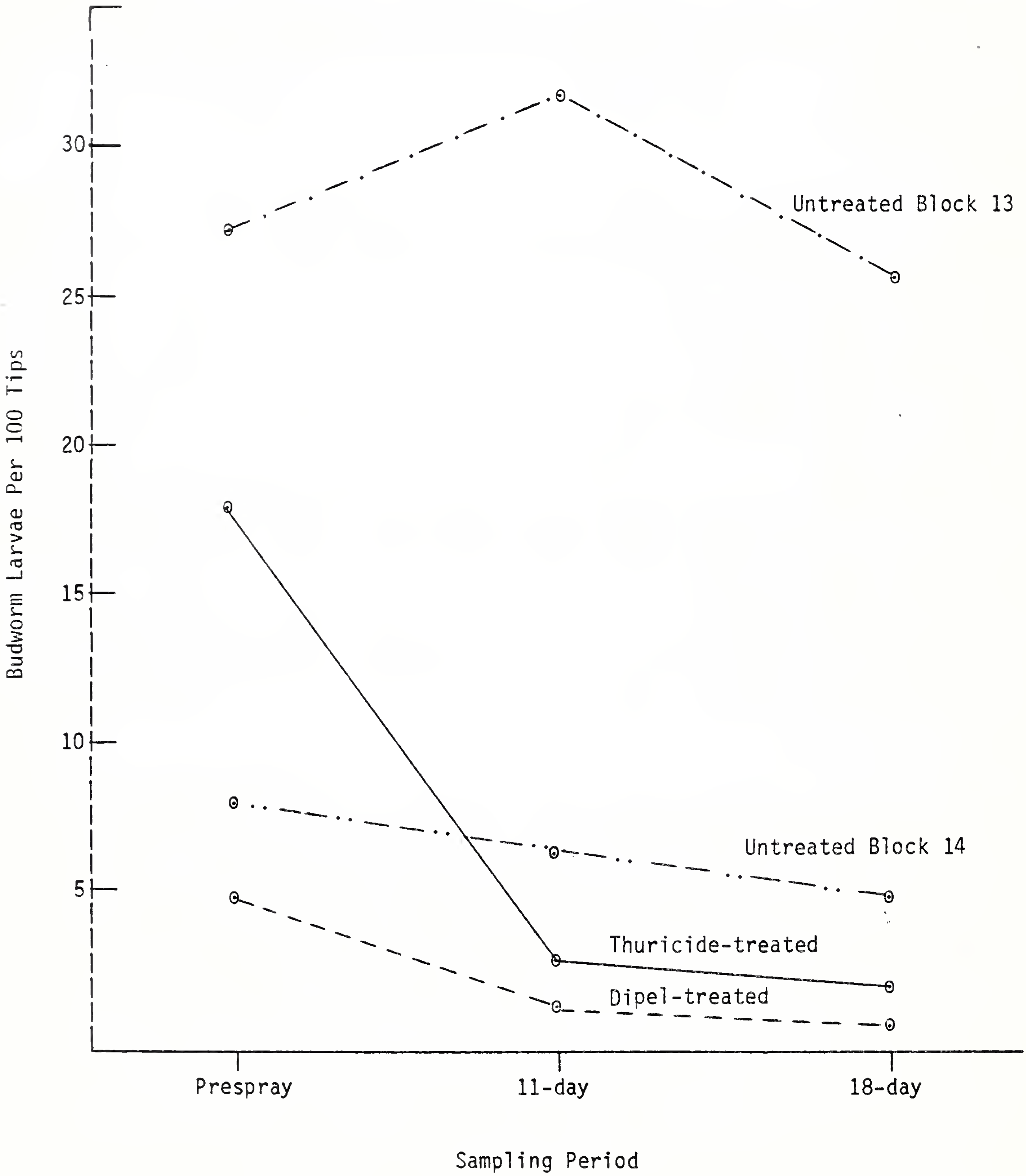
2/ Abbott's adjustment = $1 - \frac{\text{post-treated}}{\text{pre-treated}} \quad \frac{\text{pre-untreated}}{\text{post-untreated}} \quad 100$

TABLE 3. Jack Pine Budworm Larval Populations and Unadjusted Mortalities by Thuricide-treated, Dipel-treated, and Untreated Blocks, Nebraska National Forest, 1980.

Block No.	No. of 5-Tree Clusters	Larvae per 100 Tips						Unadjusted Mortality (percent)	
		Prespray		Postspray					
				11-day		18-day		11-day	18-day
		Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	Mean
Thuricide-treated									
1	4	17.4	7.2	0.5	0.1	1.0	0.3	97.1	94.3
8	6	18.6	6.3	5.0	1.7	4.7	1.4	73.1	74.7
10	4	26.6	7.5	3.4	1.6	1.2	0.5	87.2	95.5
12	3	11.1	3.2	2.1	0.7	0.8	0.2	81.1	92.8
Dipel-treated									
5	13	5.0	1.4	1.1	0.5	0.7	0.2	78.0	86.0
Untreated									
13	5	28.3	4.8	33.3	5.9	25.7	4.4	-17.7[1/]	9.2
14	5	9.1	5.5	7.0	4.2	5.4	3.3	23.1	40.7

[1/] This apparent increase in population during the period between prespray and 11-day postspray sampling was probably due to the large variance of larval numbers between branches on the same tree.

FIGURE 3. Jack Pine Budworm Larval Populations for Thuricide-treated, Dipel-treated, and Untreated Blocks, Nebraska National Forest, 1980



Egg masses were found only in Blocks 5, 8, and 13 and only one egg mass was found in Dipel-treated Block 5. Block 8, which had been treated with Thuricide, had an average of 1.2 sound egg masses per 100 tips. The adjacent untreated Block 13 had an average of 0.3 sound egg masses per 100 tips.

PROBLEMS

Many problems were experienced during the incipient stages of this project. The decision to approve the Environmental Assessment and, thus, to proceed with the project was made at a late date. This allowed very little time to submit and get bids on contracts for aerial spraying and pesticide mixing equipment, and for purchasing the insecticide.

Drastic cuts were made in allotted mileage for this project and in the number of seasonal employees. Consequently, it was not possible to conduct a scientifically sound pilot project which would produce statistically sound data.

The primary operational problem encountered was that the initial spray block marking system was inadequate which resulted in some skips in the areas sprayed on the first day. This was corrected and the remainder of the spray operations went quite well. No significant equipment failures were experienced.

RECOMMENDATIONS

It is imperative that the decision to proceed with a pilot suppression project such as the one attempted be made during January, at the latest, of the year of the project. This would allow adequate time to prepare and receive bids on contracts and to coordinate all the many aspects of the project.

The Regional Office and the National Forest must make firm commitments, based upon recommendations of the project leader, as to the number of people that will be allowed to work on the project, the number of vehicles and miles allotted, and the amount of money allotted. If these recommended targets cannot be met, the project should be cancelled. Otherwise, the result will be lack of data needed for a good statistical analysis, and thus there will have been very little gain of useful information.

The radio communications equipment should be on hand 3 or 4 weeks before the start of the project field work so that any malfunctions can be corrected before need of the equipment is critical.

For this project the insecticide mixing system consisted of materials purchased by the USDA Forest Service. This seemed to be much less desirable than having the spray aircraft contractor provide the pesticide mixing equipment.

Provisions should be made in the spray contracts for inspection and calibration of the aircraft at least one month before the proposed start of the project.

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ADDENDUM

In June 1981, one year after treatment, a survey was conducted to determine the population level of the jack pine budworm. Each of the treatment and check blocks was visited. Four 24-inch branch samples were taken from the mid-crown from each numbered tree in 31 sample plots. The branches were examined for budworm larvae and/or budworm feeding damage on 1981 foliage.

A total of 620 branch samples were collected from 31 plots. Only one budworm larva was found. Feeding damage was not detected on 1981 foliage in any of the plots that were visited. The cause(s) of this drastic population decline is(are) not known.